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ABSTRACT

Environmental psychologists are interested in the cognitive processes involved in mental maps. Multidimensional scaling was used to examine the geographic placement of buildings and their perceived attributes by undergraduate and graduate students, and by faculty and staff of a university (N=30). Nine college buildings were selected. Subjects responded to a questionnaire by rating the similarity between buildings and the attributes of academic orientation, size, height, leisure orientation, and administrative orientation; and by estimating the shortest distance between buildings. Two dimensions were used by subjects to rate the similarity of buildings. The first dimension included academic, administrative, size, and height variables; the other used leisure orientation. The results indicated that males and females were both relatively accurate in estimating differences between buildings, while men were more accurate in estimating straight-line differences. A cognitive map was produced and the veridicality was tested statistically. (ABL)

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COGNITIVE MAPS OF A COLLEGE CAMPUS: A MULTIDIMENSIONAL SCALING ANALYSIS

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Running head: MAPS

Paper presented at the Annual Convention of the Southwestern Psychological Convention, Austin, TX, April 1985, and the Annual Convention of the American Psychological Association, Los Angeles, CA, August 1985.

Abstract

Perceptions of the location of and similarity between nine campus buildings were examined with multidimensional scaling. Subjects filled out a questionnaire composed of three parts: (1) rating the similarity between the buildings in all possible pairs; (2) rating the buildings on five attributes; and (3) estimating the physical distance between the buildings in each pair. For the distance data, correlations between actual and estimated distances were significant for each sex and for the group as a whole. The two-dimensional ordinal solution corresponded closely to a solution derived from actual distance measurements. For the similarity data, the two-dimensional ordinal stimulus configuration was used as an estimation space, with the attribute ratings used as dependent variables, in univariate regression procedures. The regressions showed one dimension reflecting a combination of size, height, administrative orientation, and academic orientation, with a second dimension of leisure orientation. The usefulness of MDS for conducting environmental psychological research is discussed.

This paper concerns mental maps, defined by Beck and Wood (1976) as "sketch products created by experimental subjects" (p. 200). These maps give an aerial view of a geographic area, with specific locations being indicated and named by the subjects.

The methodology for studying these mental maps was dominated in the 1960's by the free sketch map developed by Lynch (1960). In this procedure, subjects are asked to draw a map of an area. They are given no information by the experimenter about the area and must remember the details from previous contacts with the area. While the maps thus produced can be examined for content (the amount of richness or detail) and veridicality (the general location and named accuracy of map elements), this technique has serious limitations as a research tool. For instance, an error made early in the sketching is compounded as additional elements are added to the map. These distort the map and may not be corrected by the subject even if he/she is aware of the error, because doing so would sacrifice the work done up to that point.

During the 1970's, environmental psychologists began using techniques that demanded less of the subject. These are of two main types: (1) giving the

subject a predrawn base map to which the subjects adds details (Orleans & Schmidt, 1972; Regnier, 1974); or (2) using a mapping language, with which the subject creates his/her own base map, then adds layers for areas and symbol attributes for places within those areas (Wood, 1973; Wood & Beck, 1971). These two techniques have enabled researchers to examine the map-making process in greater detail than was possible with the free-sketch procedure. By breaking the process into parts and studying the parts and their inter-relationships, researchers have been able to construct a hypothesized set of cognitive operations necessary for map production.

The study of environmental cognition is a relatively new area of research. Lynch's (1960) Image of the City is cited by many as its starting point, although Moore (1979) states that seminal papers appeared earlier in sociology, geography, and psychology. In discussing environmental differences, he says that findings thus far indicate that people recognize and recall buildings in terms of (1) what they do there, (2) where they are, and (3) what they look like.

Genereux, Ward, and Russell (1983) examined the first of these environmental factors by asking subjects to rate 20 places on each of 11 behaviors in terms of (1) suitability and (2) expected frequency of occurrence. A three-way interaction was found involving place suitability, expected behavior, and location, indicating that different patterns of interaction exist between place and behavior. Baird, Noma, Nagy, and Quinn (1976) had students rate the expected frequency of activities in different locations in campus buildings. Actual observations of those activities in those locations were also made. Results indicated that subjects overestimated the absolute frequency of those behaviors, but that the relative frequencies were in close agreement with the observations.

Groat (1982) examined the appearance or "look" of buildings as perceived by different subject groups. She had architects and accountants sort pictures of buildings representing Modern and Post-Modern architectural styles into groups based on perceived similarity, then had them label the categories thus formed and the criterion by which he/she had sorted the buildings. She found that the subject groups employed different sets of criteria for evaluating buildings and

that the accountants did not perceive any difference in architectural style among the buildings.

Several observations can be made at this point. First, map-making tasks have helped establish cognitive models for the production of geographic maps of areas. However, as Beck and Wood (1976) suggest, the resulting mental or cognitive maps are usually far from accurate, and no statistical procedures exist for assessing either the relative accuracy of the map or individual differences between map makers. Second, buildings have been used as stimuli for tasks involving similarity ratings (Groat, 1982), but no studies have attempted to identify dimensions used by subjects to judge that similarity. Finally, separate methodologies have been used to produce maps of territories and to study the perceived attributes of buildings and other elements within those territories.

Another methodology for the study of environmental perceptions that has not received widespread use in the area is multidimensional scaling (MDS). MDS data consist of ratings of the distances between stimulus objects. In MDS research the "distances" usually used as data are perceived similarity of dissimilarity between stimulus objects (e.g., buildings), but the

technique can be applied to physical distance estimates as well.

In this paper we use multidimensional scaling (MDS) to examine both the geographic placement of buildings in the environment and their perceived attributes. By using physical distance estimates with MDS, we can produce a configuration of points representing buildings that corresponds to a cartographic map and statistically compare this to the actual configuration of buildings. And by using similarity ratings, we can attempt to identify the dimensions by which subjects judge that similarity.

Method

Subjects

Two groups of subjects were used. The first (7 women, 9 men) was composed of undergraduates fulfilling an experimental participation requirement. The second (6 women, 8 men) was comprised of graduates students, faculty, and staff of the Department of Psychology at the University of Oklahoma who volunteered to participate. Preliminary analyses were performed on each group separately. No major differences were noted, so the groups were combined to produce the data base for this paper.

Stimulus Objects

Nine buildings were selected from among those present on the University of Oklahoma campus. Eight of them are in an area, bordered by major north-south and east-west streets, that comprises the main campus. The ninth building is directly across the street to the east of this area in the extreme southeast corner.

One building (the library) is located slightly north and west of the center of this rectangular main-campus area. The other eight were selected such that (1) there were two buildings in each quadrant of the campus area and (2) the buildings were likely to be familiar to all subjects. These included the student union, an art museum, an athletic dormitory, and various other buildings that contained both coassrooms and administrative offices.

Materials and Procedure

Both the judgements of similarity and the estimation of physical distance were based on paired comparison judgments of the stimulus objects. An effective and unbiased method for pairing the stimuli was required to construct the questionnaire. The Ross (1934) algorithm, which balances both space effects (stimuli appear an equal number of times as first and

second items in the pairs) and time effects (pairs in which a stimulus appears are equally spaced throughout the list) was used. Davison (1983) suggests that the Ross ordering is the best design for MDS paired comparison research.

The questionnaire contained three sections, presented in the following order:

(1) Subjects were instructed to rate the similarity between buildings in each pair. Ratings could range from 1 (very similar) to 9 (very dissimilar). Responses were indicated by circling the appropriate number in a horizontal array of numbers. Subjects were told that they could "judge the similarity between the buildings in any way" they chose.

(2) Subjects then rated each building on 9-point scales representing the attributes of academic orientation, size, height, leisure orientation, and administrative orientation. Larger numbers represented more of the attribute. The scales were anchored at each end by adverb-adjective combinations consonant with the numbering scheme.

(3) Finally, subjects were asked to estimate the shortest distance in yards in a straight line between

the buildings in each pair and to write their estimate on the line to the right of the pair.

Results

All analyses were performed using procedures available in the SAS software package (SAS Institute, 1982a; SAS Institute, 1982b; SAS Institute, 1983). Results will be presented separately for distance and similarity data.

Distance Data

The actual distances between the buildings were obtained from a scaled map of the campus prior to data collection. The shortest distance between the outsides of the buildings in each pair was used as the actual distance, since this conformed best to the instructions given to the subjects. (The appropriateness of this measure will be addressed more fully in the Discussion section.) Correlations were computed between the actual distances and average estimated distances for each sex separately and for the total sample. Pearson, Spearman, and Kendall correlations were all significant, $p < .0001$, and quite large, supporting the notion that the distance estimates were relatively accurate. The correlations are presented in Table 1.

Insert Table 1 about here

A general linear model (GLM) test was performed to determine whether males and females estimated distances with the same relative accuracy. Actual distance was treated as the dependent variable, and estimated distance, sex, and their interaction were used as independent variables, in a linear regression. The test of the interaction term was significant, F (1,68) = 16.33, $p < .0001$, indicating unequal regression slopes for males and females. Since the male correlations were higher, this suggests that males estimated the distances more accurately than females. This procedure is the exact test for which the Fisher r to z transformation z - test is an approximation.

PROC ALSCAL was used to perform three sets of multidimensional scaling analyses. First, a Euclidean scaling was performed on the actual distance data, in order to produce a target configuration for comparison with the configurations derived from subject data. This configuration is represented in Figure 1 by stars. Second, PROC ALSCAL was used with MODEL = INDSCAL to produce 3 individual differences scalings of the

subject data, one each for total sample, males, and females. Finally, the MODEL = EUCLID option was utilized to produce 3 replicated MDS (RMDS) scalings, one each for the same groups. The INDSCAL and RMDS scalings were done using ordinal, interval, and ratio level measurement in two dimensions, while the first was done only for ordinal level measurement in two dimensions. The INDSCAL and RMDS stimulus configurations for the total group are also presented in Figure 1.

Insert Figure 1 about here

The two-dimensional ordinal solutions were seleted as the best ones for the data. Using a technique developed by Schonemann and Carroll (1970) and Gower (1971, 1975), the stimulus configurations were compared to the target configuration presented in Figure 1. The congruence coefficients for the total group and for each sex are presented in Table 2. All coefficients are significant, $p < .0001$. Davison (1983) suggests that congruence coefficients over .9 indicate an excellent match between target and obtained configurations, while those between .7-.9 are fair-to-good

fits. Figure 1 shows all three configurations together, with circled elements representing identical buildings.

Insert Table 2 about here

The same GLM procedure used to examine the relative accuracies of the distance estimates was used to test whether the stimulus configurations produced from the male and female distance estimates corresponded equally well with the target configuration. The F - test for the relative accuracies of the RMDS solutions was F (1,32) = .36, n.s.; for the INDSCAL solutions, F = .79, n.s. Therefore, although males estimated the straight-line distances with significantly greater accuracy than females, there was no sex difference in the relative accuracy of the overall derived stimulus configurations, i.e., the cognitive maps.

Similarity Data

PROC ALSCAL was utilized with MODEL = INDSCAL to analyze the similarity data. The ordinal-level solution in two dimensions was chosen as the preferred solution. Following a procedure by Kruskal and Wish

(1978), an attempt was made to tentatively identify the dimensions. The five rating scales obtained from the second part of the questionnaire were each regressed on the stimulus coordinates in several univariate regressions. The direction cosines and R-squared values are presented in Table 3. Dimension 1 is related to leisure orientation, and Dimension 2 is related to all the other rating scales used in this study: academic and administrative orientation, size, and height. On this particular campus, these four features are highly confounded in the 9 buildings rated. Thus, the similarity data cannot be used to identify which of these four psychological continua subjects perceived as most salient. An ANOVA was performed on the ALSCAL-derived flattened subject weights (see Shiffman, Reynolds, & Young, 1981, p. 310). It failed to show a difference between the sexes, indicating that males and females did not differ in how they used the dimensions extracted by the multidimensional scaling. The stimulus configuration derived from the similarity data is presented in Figure 2.

Insert Table 3 and Figure 2 about here

Discussion

When rating similarity between buildings, subjects in this study seemed to use two dimensions: leisure on the one hand and academic orientation, administrative orientation, size, and height on the other. The relative positions of the buildings on the letter dimension correspond fairly well to overall size, with large buildings being on the right and small buildings being on the left. On the other dimension, identified as leisure orientation, the ordering is: student union, library, art museum, athletic dorm, engineering center, journalism center, physical sciences center, an arts and sciences office/classroom building and, finally, the botany-microbiology center.

Males and females were both able to estimate the distances between the buildings with relative accuracy. This accuracy is reflected both in the correlations between estimated and actual distance shown in Table 1 and the congruence coefficients shown in Table 2. Sex differences involving spatial abilities have been noted in some studies of environmental cognition (for

example, Orleans & Schmidt, 1972). Both Beck and Wood (1976) and Moore (1979) say that performance differences in such mapping tasks are due to socialization and upbringing rather that biological differences. A sex difference was found in the present study involving the relative accuracies of the distance estimates. It should be remembered, however, that all of the correlations in Tables 1 and 2 are significant, $p < .0001$. In addition, a completely different procedure for producing maps was used here, and the cognitive maps thus produced are not directly comparable with those produced by other methods.

The correlations found between actual and estimated distances need further comment. The actual distance between buildings was defined to be the shortest possible distance between the buildings, e.g., from near corner to near corner. It is possible that subjects were actually thinking of the distance between entry doors of those buildings, or perhaps between the centers of the buildings. The net result of such response sets should be to overestimate the actual distance between any two buildings. While it is impossible in the present study to determine whether such a response set was being used, the data tend to

disconfirm such a hypothesis. The mean distances for the total group were compared to the actual distances. In 11 cases, the distances were overestimated; in 25 cases they were underestimated. These facts, coupled with the correlations in Table 1, suggest that subjects gave distance estimates that bracketed the actual values and do not indicate any consistent tendency to overestimate.

In summary, we found that subjects of both sexes were able to accurately estimate the relative distances between the buildings on campus, and that men were relatively more accurate that women. Further, we used this information to produce a cognitive map whose veridicality was tested statistically. We also found that these subjects were using two dimensions to rate the similarity of the buildings, one identified as academic-administrative-size-height, the other as leisure.

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Table 1

Correlations of Actual with Estimated Distances

	Sample		
Correlation	Total	Males	Females
Pearson	.9685	.9714	.9193
Spearman	.9508	.9737	.9115
Kendall	.8299	.8744	.7542

Table 2

Correlations of Actual with Subject-Derived Stimulus Coordinates

	Sample		
Correlations	Total	Males	Females
RMDS	.91044	.93256	.87406
INDSCAL	.95832	.96270	.90288

Table 3

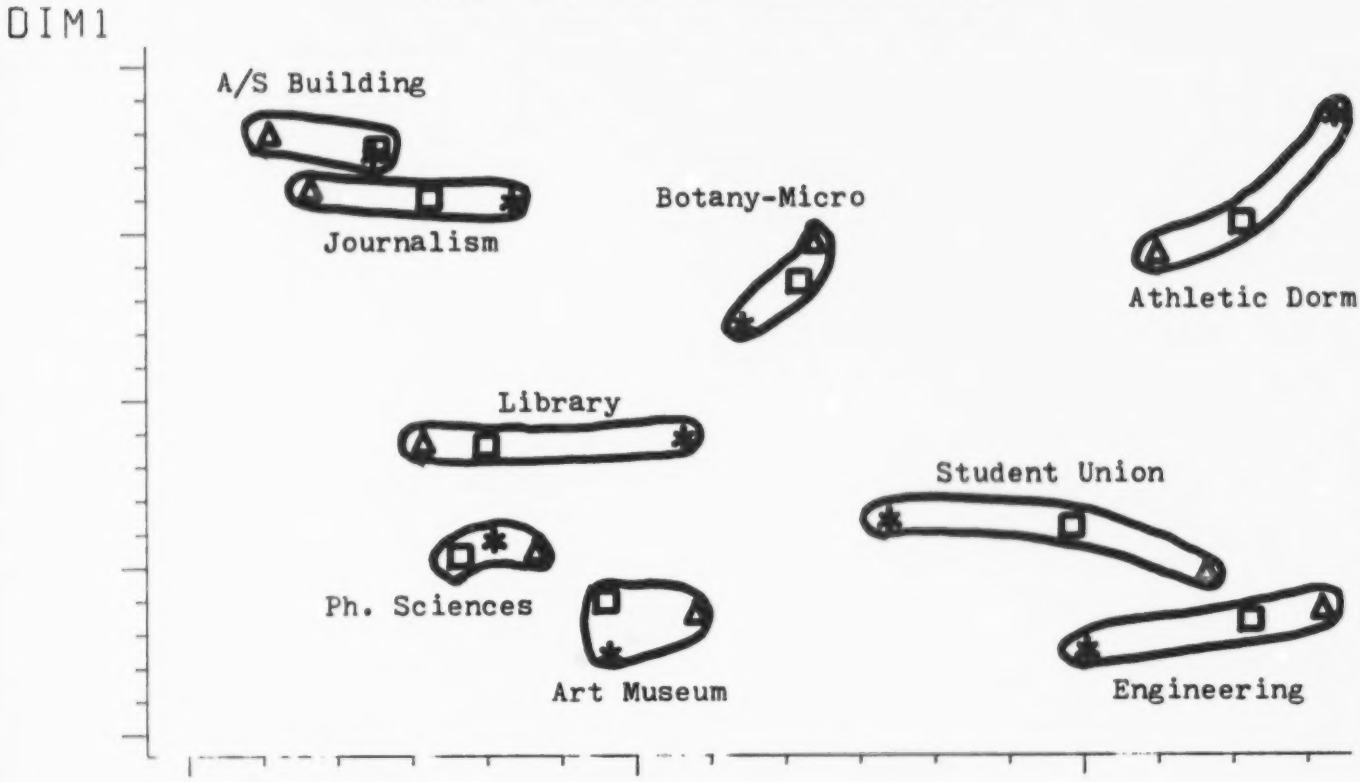
Direction Cosines for Similarity Data

	Rating Scale				
Dimension	Aca	Size	Height	Lei	Admin
1	.437	-.280	.330	-.890**	.342
2	.899*	.960*	.944*	-.456	.940*
R^2	.585	.681	.597	.453	.683

* p < .05

** p < .11

STIMULUS CONFIGURATIONS FOR TARGET, RMDS, AND INDSCAL SOLUTIONS



TARGET=STAR
RMDS=TRIANGLE
INDSCAL=SQUARE

STIMULUS CONFIGURATION FOR SIMILARITY DATA